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Estimating Dislodgeable Foliar Residues and Turf Transferrable Residues in Occupational and Residential Postapplication Exposure Assessments

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1.0 Summary

Dislodgeable foliar residues (DFR) and turf transferrable residues (TTR) are measurements of pesticide residue on foliage and turf that can be transferred to human skin and clothing. They are used by Health Canada's Pest Management Regulatory Agency (PMRA) when determining postapplication human exposure and risk to pesticides. The United States Environmental Protection Agency (USEPA) recently revised their DFR and TTR default values based on a large, robust database of studies. The PMRA has similarly updated the Canadian default DFR and TTR values for use when chemical-specific DFR or TTR studies are not available; these are presented in this document.

2.0 Purpose

The purpose of this document is to provide an update to stakeholders on the default DFR and TTR values used by the PMRA when calculating postapplication worker exposure for agricultural and residential risk assessments.

'Default' refers to the value used when a chemical-specific DFR or TTR study is not available. Default values are established after a rigorous review of the available scientific data, and are updated periodically, as more data become available. They are considered to be relatively upper bound, or conservative, to address exposures to most chemicals; however, in some cases, the defaults may potentially underestimate DFR or TTR for highly persistent chemicals.

Registrants are encouraged to submit chemical-specific DFR or TTR data when available, or as warranted, in order to reduce uncertainty and increase confidence in the postapplication risk assessment.

3.0 Background

Under the *Pest Control Products Act*, the PMRA has the responsibility to protect the health of Canadians from unacceptable risks associated with pesticide use. In order to assess potential risks of pesticide use to the health of Canadians, the Agency must be able to estimate their potential exposure to pesticides and any pesticide transformation products that might be of toxicological concern. The exposure assessment must be comprehensive and include potential pesticide exposure from all sources and by all routes (aggregate exposure[1]). Estimating potential exposure to persons entering an area that was treated with pesticides is an important part of occupational and residential exposure assessments.

[1] Aggregate exposure refers to exposure to a single chemical by multiple pathways (through food, drinking water and residential use) and routes of exposure (oral, dermal and inhalation).

Postapplication exposure assessments estimate potential exposure to pesticide residues that remain in an area and could be contacted by a given person when they enter a treated area. These residues are typically on the foliage of plants or turf, and can be transferred to a person's clothing or skin when contacted. Residues that are on plant foliage and are available for transfer are referred to as dislodgeable foliar residues. Residues that are on the surface of turf and are available for transfer are referred to as turf transferrable residues. Although DFR and TTR are similar in that they are measurements of residues available for exposure, they are measured using different techniques and, therefore, cannot be used as surrogate values for one another.

To estimate postapplication exposure, the PMRA combines DFR and TTR data, transfer coefficient (TC)[2] values and the duration of time a person would be in contact with treated foliage. Mathematically, this is expressed as follows.

Postapplication Dermal Exposure Calculation Equation

$$\textbf{Dermal Exposure (mg/day)} = \textbf{DFR/TTR (mg/cm}^2\textbf{)} \times \textbf{TC (cm}^2\textbf{/hr)} \times \textbf{Activity Duration (hr/day)}$$

Generally, residues are highest immediately after an application (initial DFR or TTR) and decline over time due to various mechanisms including transformation into smaller compounds and mechanical removal due to rain. As the degree of potential exposure is related to the amount of chemical remaining on the foliage, exposure should decrease over time.

DFR and TTR are typically determined using chemical-specific studies, as the chemical properties of a pesticide product can influence the residue levels remaining on foliage and turf following application. In the absence of chemical-specific studies, DFR and TTR can be estimated using generic assumptions for both the initial residue available (expressed as a percentage of the application rate) and the residue dissipation (expressed as a percentage per day). The PMRA has developed scientifically-derived assumptions for the estimation of DFR/TTR values where reliable, chemical-specific data are not available; the use of these standard assumptions or 'default values' by regulators is necessary in order to determine the acceptability of risk in the absence of a complete exposure study database. The default values used by the PMRA for DFR and TTR are harmonized with those determined by the USEPA. The USEPA recently revisited these default values (USEPA, 2012a,b) and these are discussed in this document.

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[2] A transfer coefficient is an empirical measure of residue transferability from the foliage of plants or turf onto a person's skin or clothing and are determined from passive dosimetry exposure studies and concurrent DFR or TTR studies. For more information, please refer to PRO2014-02: *Updated Agricultural Transfer Coefficients for Assessing Occupational Postapplication Exposure to Pesticides.*

4.0 Dislodgeable Foliar Residues

Background

During the 1970s, a standard technique was developed for determining the amount of pesticide residue on treated foliage that is available for transfer to a worker (Gunther, *et al.*, 1973; Iwata *et al.*, 1977). The procedure involved collecting a known surface area of foliage (leaf punches or whole leaves) and agitating the leaf sample in an aqueous surfactant solution to remove residues from the leaf surface. Residues removed in this manner represent residues that are retained on the leaf surface, as opposed to those that have penetrated into the leaf itself. in this manner were termed DFR. These dislodgeable residues can be transferred to a person's skin and clothing when they contact plant foliage.

In the absence of a chemical-specific DFR study, 20% of the application rate had been used by the PMRA to represent the initial DFR, with a dissipation rate of 10% per day. These default values from the USEPA Residential Standard Operating Procedure (SOP) (1997) were determined from the review of registrant-submitted data, and were assumed to represent a value that is protective of health without being unreasonably conservative.

Updated DFR Values – Outdoor Field Crops

In the 2012 USEPA Residential SOPs, 19 studies (60 data points) conducted by the Agricultural Reentry Task Force, a task force of pesticide registrants, were analyzed for the purposes of establishing generic dislodgeable residue factors. In this analysis, the initial residue values and daily dissipation rates from the dataset were pooled into composite datasets for the purposes of providing generic transferable residue factors for exposure assessment. Analysis of DFR data from these field studies for various types of crops and active ingredients indicated that the average amount of dislodgeable residue on the day of application was 25% of the application rate. As such, this value has been selected by the USEPA as the revised default value for the initial DFR level. The value of 10% per day was selected as the default daily dissipation rate based on the geometric mean dissipation value of 16% (standard deviation of 2.1%) from the dataset. For a detailed description of the analysis, refer to Chapter 4.2.2 of the USEPA Residential SOPs (USEPA, 2012b).

The USEPA analysis was based on a large database that spans a variety of crop types and active ingredients; as such, the resulting revised default values adopted by the USEPA are considered to be more robust than the values from the 1997 USEPA Residential SOP. Although not conducted in Canada, the studies used in the USEPA analysis were determined to be representative of the range of residues that would be measured under Canadian climatic conditions. Therefore, the PMRA is also revising the default value for the initial DFR level (in other words, the day of application) to 25% of the application rate for scenarios where chemical-specific data are unavailable. The default dissipation rate of 10% per day will be maintained for outdoor field crops based on the analysis of the USEPA.

DFR Values for Greenhouse Crops

Due to differences in application technology and environmental conditions (humidity, temperature, rainfall, ultraviolet light, etc), an outdoor dissipation rate is not considered to be appropriate to estimate dislodgeable residues in greenhouses. As the analysis performed by the USEPA did not include crops grown in greenhouses, the default daily dissipation rate was considered to be limited to outdoor field crops. At this time there is limited information on which to estimate a default daily dissipation rate for greenhouse crops. The limited data that were available to PMRA indicate that dissipation in greenhouses is much slower than outdoors. Therefore, in the absence of adequate data to determine dissipation in greenhouses, the assumption of no dissipation (in other words, 0% per day) will be maintained for greenhouse crops. Registrants are encouraged to submit chemical-specific DFR data including dissipation for products used in greenhouses.

A summary of the default DFR values used by the PMRA is shown in Table 1.

Table 1 Summary of Default DFR Values Used by the PMRA

Scenario	Previous Assumptions	Current Assumptions
Outdoors	**Initial (Day 0) DFR:** 20% of the application rate[a] **Dissipation Rate:** 10% per day	**Initial (Day 0) DFR:** 25% of the application rate[a] **Dissipation Rate:** 10% per day
Greenhouse	**Initial (Day 0) DFR:** 20% of the application rate[a] **Dissipation Rate:** 0% per day[b]	**Initial (Day 0) DFR:** 25% of the application rate[a] **Dissipation Rate:** 0% per day[b]

[a] Expressed as mass active ingredient per leaf surface area ($\mu g/cm^2$), and assuming all the pesticide applied lands on the foliage (application rate in g a.i./ha converted to g a.i./cm^2).

[b] Due to differences in application technology and environmental conditions (humidity, temperature, rainfall, ultraviolet light, etc.), the outdoor dissipation rate is not considered to be appropriate for estimating dislodgeable residues in greenhouses. This is supported by the limited data available to PMRA. At this time, there is no default dissipation rate for greenhouses, so no dissipation is assumed (in other words, 0% per day).

5.0 Turf Transferrable Residues

Background

During the 1990s, a standard technique was developed for measuring the amount of residues on turf that are available for transfer onto a person's skin or clothing. This technique, called the Modified California Roller method, was developed by the industry-based Outdoor Residential Exposure Task Force and supported by Health Canada's PMRA, the California Department of Pesticide Regulation , and the USEPA, as it produced the most consistent results across samples, active ingredients, formulation types and time, than the other available techniques (Fuller, *et al.*, 2001). The Modified California Roller method involves pushing a weighted roller five times across a 0.7 m^2 area of cotton cloth that is securely fastened to turf-covered ground in order to collect residues. Residues removed in this manner represent residues that are on the surface of turf and available for transfer; which are termed TTR.

In the absence of a chemical-specific TTR study, the PMRA's default value for turf transferrable residues had been 5% of the application rate for the initial (day 0) TTR value with a dissipation rate of 10%/day. This initial TTR default value was from the USEPA Residential SOP (2001) and was based on evidence that suggested the transferability from the California Roller technique was less than 5% of the application rate (~1 to 3% observed in various indoor carpet and proprietary studies). It was noted that studies conducted with the Modified California Roller method appeared to have much lower transfer efficiency than the original version of the roller used to determine the initial TTR default value.

Updated TTR Default Values

In the 2012 USEPA Residential SOPs, 59 studies (165 data points) that collected turf transferrable residues using the Modified California Roller method were analyzed. During the analysis of these studies, it was determined that there was no statistical difference between residues resulting from liquid, wettable powder (applied as a spray), or water dispersible granular (applied as a spray) applications; as a result, these data were combined for analysis. Granular data were analyzed separately. The arithmetic mean for the initial TTR value from these studies was 0.93% and 0.17% of the application rate for liquid and granular applications, respectively. Based on this, the USEPA selected a value of 1% and 0.2% of the application rate as the initial TTR default values for liquids/wettable powders/water dispersible granules and granules, respectively. It was assumed that the foliar dissipation rate observed in DFR studies would be the same as that for turf. As such, the default daily dissipation rate of 10% from the DFR analysis was also applied to TTR. For a detailed description of the analysis, refer to Chapter 3.2.8 of the USEPA Residential SOPs (USEPA, 2012b).

The USEPA analysis was based on a large database representative of the Modified California Roller method, which is currently used for TTR studies. As such, the resulting revised default values adopted by the USEPA are considered to be more appropriate than the values from the 2001 USEPA Residential SOP when using TCs that were derived using TTR studies conducted with the Modified California Roller method.[3] Although not conducted in Canada, the studies used in the USEPA analysis were determined to be representative of the range of residues that would be measured under Canadian climatic conditions. Therefore, the PMRA is also revising the peak TTR default value from 5% to 1% of the application rate for turf uses for all product formulations, including granular. The default dissipation rate of 10% per day will be maintained based on the analysis of the USEPA.

Although the analysis in the 2012 Residential SOPs indicated that there was a difference in peak residues between liquid and granular applications, most TCs currently used by the PMRA in postapplication exposure assessments are based on studies conducted with liquid formulations. Although the USEPA established a peak default value of 0.2% for granular formulations, use of this default with TCs determined using non-granular formulations may underestimate exposure. Only in the situation where a TC is generated based on a granular application would it then be appropriate to use the default peak residue value of 0.2% of the application rate.

A summary of the default TTR values used by the PMRA is shown in Table 2.

Table 2 Summary of Default TTR Values Used by the PMRA

Formulation	Previous Assumption	Current Assumption[a]
All formulations[b]	**Peak (Day 0) TTR:** 5% of the application rate[c] **Dissipation Rate:** 10% per day	**Peak (Day 0) TTR:** 1% of the application rate[c] **Dissipation Rate:** 10% per day

[a] These defaults are only to be applied if the collection method in the TTR study used to determine the transfer coefficient was a Modified California Roller. If the TC was based on a TTR study where another TTR collection method or DFR turf data (for example, turf clippings) were used, then this default value is not appropriate.

[b] As most TCs currently used by the PMRA are based on liquid applications, the 1% peak TTR default value should be used for all formulations. For TC values that are generated based on a granular formulations, then the lower default of 0.2% of the application rate for granules could be used with this TC.

[c] Expressed as mass active ingredient per turf surface area ($\mu g/cm^2$), and assuming all the pesticide applied is deposited on turf (application rate in g a.i./ha converted to g a.i./cm^2).

[3] As the method of collection and formulation used in DFR or TTR studies could have an impact on the calculated TC, it is important that the conditions in the DFR or TTR study used to determine a TC be maintained when using that TC in risk assessments.

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